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Turbulent kinetic energy spectra of solar convection from New Solar Telescope observations and realistic magnetohydrodynamic simulations

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Abstract

Turbulent properties of the quiet Sun represent the basic state of surface conditions and a background for various processes of solar activity. Therefore, understanding the properties and dynamics of this 'basic' state is important for the investigation of more complex phenomena, the formation and development of observed phenomena in the photosphere and atmosphere. For the characterization of turbulent properties, we compare the kinetic energy spectra on granular and sub-granular scales obtained from infrared TiO observations with the New Solar Telescope (Big Bear Solar Observatory) and from three-dimensional radiative magnetohydrodynamic (MHD) numerical simulations ('SolarBox' code). We find that the numerical simulations require high spatial resolution with a 10-25 km grid step in order to reproduce the inertial (Kolmogorov) turbulence range. The observational data require an averaging procedure to remove noise and potential instrumental artifacts. The resulting kinetic energy spectra reveal good agreement between the simulations and the observations, opening up new perspectives for detailed joint analyses of more complex turbulent phenomena on the Sun and possibly on other stars. In addition, using the simulations and observations, we investigate the effects of a background magnetic field, which is concentrated in self-organized complicated structures in intergranular lanes, and observe an increase of the small-scale turbulence energy and its decrease at larger scales due to magnetic field effects.

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